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RELATIONSHIPS BETWEEN CULTIVATION TECHNIQUES, VEGETATION, PEDOLOGY AND EROSION ON EXTENSIVELY CULTIVATED AND ABANDONED AGRICULTURAL AREAS IN THE PUTNOK HILLS

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Pedological and coenological investigations were made around the villages of Alsószuha and Gömörszőlős, in the Putnok Hills microregion, which forms part of the Northern Hungarian Mountains. These were complemented with laboratory nutrient analyses, giving the opportunity to compare the pedological relationships and erosion of natural and ploughed areas. Arable lands can often be found on steep slopes. The brown forest soil types characteristic of these areas are less sensitive to erosion, but they suffer significant damage when cash crops are hoed regularly even on steep slopes.

Coenological data indicative of the previous farming system are presented for three plots near Alsószuha. Regular mowing resulted in a large number of plant species even 10 years after cereal production was abandoned. The lack of regular mowing on a plot with a similar farming history, however, resulted in the dominance of aggressive weeds. The species on the third plot showed that the 42 years that had elapsed since cereal production was abandoned, followed by grazing until 1990, ensured enough time for revegetation and the generation of a secondary grassland (slope steppe) in a close-to-natural state. Invasive weeds were absent from all the observed plots.

Key words: pedology, coenology, erosion, land abandonment, Putnok Hills

Introduction

The studied area, the Putnok Hills microregion, is part of the Northern Hungarian Mountains mesoregion, ranging from the Sajó Valley to the southern border of the main part of the Aggtelek National Park (Marosi and Somogyi, 1990).

Traditional land use methods were observed from the point of view of their influence on habitats in a close-to-natural state. These areas are extremely important for nature conservation because valuable plant taxa can only be preserved for future generations by sustaining the management patterns used for hundreds of years. The plant communities and protected species in the studied area were described for various landscape management methods by Malatinszky (2004).

The natural conditions of the area are suited to forestry, pasture management and crop cultivation. Ancient agricultural activities carried out in diverse habitats resulted in specially structured landscape mosaics. Besides biological and landscape diversity, an adequate cultivation structure is also important for the preservation of soil fertility and to avoid erosion (Centeri, 2002a). Soil is one of the most important components of the landscape. Its preservation is a priority, because it is a non-renewable resource compared with the scale of the human lifetime. Eroded soil material may carry humus and important fertilizers. As much as 9 kg $ha^{-1}year^{-1}$ N, 5.5 kg $ha^{-1}year^{-1}$ P and 6.6 kg $ha^{-1}year^{-1}$ K may be lost due to erosion from arable lands (Centeri, 2002b). Detailed soil data for the Alsószuha research area were reported by Centeri and Császár (2005).

The preservation of the environment and of natural habitats is vital not only because of their effects on the human environment and due to the cost of recultivation after mining, floods and landslides or after preventable damage, but because nature and the natural environment are also valuable in themselves. However, it is difficult to measure the value of the landscape and express it in monetary terms (Csorba, 2003). The investigation of changes in landscape patterns is extremely important (Barczi et al., 1996/97).

Materials and methods

The investigated area is situated in the Putnok Hills microregion, near the village of Alsószuha, on the eastern slope of Lengyel-oldal hill, and on the Cuda area near Gömörszőlős.

Laboratory soil experiments

The amounts of AL-P_2O_5, AL-K_2O, $CaCO_3$ and soil organic matter and the pH (KCl and H_2O) were measured using standard procedures in the Department of Soil Science and Agricultural Chemistry of Szent István University.

Field soil experiments

Slopes with different vegetation cover were chosen for the investigations. In the Alsószuha area three different vegetation covers were examined on the same side of a hill. The slope angle was 12–17% on the lower slope and 17–25% on the upper slope (Fig. 1). In Gömörszőlős (Fig. 2) the upper slope had an angle of 12–17% and the lower slope 5–12%.

The field studies included sampling with a Pürckhauer soil core sampler (Finnern, 1994) and full soil profile descriptions (Stefanovits, 1992). Core sampling allowed numerous samples to be taken for the analysis of the depth of the layers, pH, colour, soil texture, carbonate content and soil type, while samples were taken from the profiles in order to analyse basic parameters.

Botanical investigations

Species names follow the nomenclature of Simon (2000). Rare species (including weeds) were compared not only with modern literature, but also with the Herbarium Carpato-Pannonicum collection in the Hungarian Natural History Museum. Coenological investigations were made on 14 September 2005 on patches of typical vegetation neighbouring the sampled arable land, using 2×2 m quadrates, based on the method of Braun-Blanquet (1964). The cover rates of the various species are given as percentages.

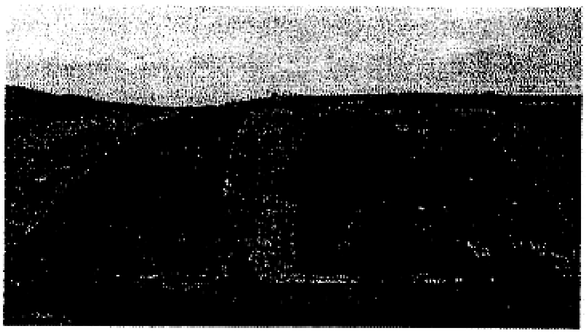

Fig. 1. Area examined near Alsószuha

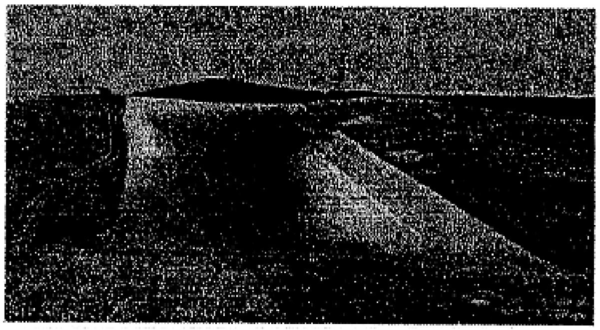

Fig. 2. Area examined near Gömörszőlős

Landscape history and management

The following sources were used for investigations on previous farming methods and the landscape history of the area: aerial photos, old military maps (on which changes in land use can be clearly traced), interviews with older inhabitants and the working plans of forest managers.

Results

An examination of the soil cover of both the Alsószuha and Gömörszőlős locations showed that they had previously been subjected to intensive land use. These areas, now used non-intensively, are the home of valuable, rare plant species and have very shallow soils, sometimes only 5–10 centimetres thick, where the loess parent rock is mixed with the humic layer. When the land has no plant cover, the effect of erosion is easily detected, because the lighter, yellowish colour of the parent material is visible on the surface.

The Gömörszőlős site was the more eroded (Fig. 2). During the spring of 2005, the plot was used for triticale production. As a result of non-intensive landscape management and the lack of pesticides, rare weed species such as *Agrostemma githago* and *Bifora radians* were found on the site. The dry slope steppes surrounding the plot were in a weedy, disturbed state, with relatively few plant species indicative of close-to-natural conditions.

The examination of the soil profile (Table 1) showed that very little of the original soil horizon remained. The top 5–15 cm layer still contained 1.57% organic matter, so the most probable scenario is that cultivation and erosion continuously mixed the upper soil layer with the lower ones, until they reached the parent material. The high $CaCO_3$ content (>20%) was also reflected by the pH (8; 8.2).

The site examined near Alsószuha (Fig. 1) was used mainly for cereal production until 1963, after which it was divided into narrow allotments. These small plots are now sown to maize, wheat, oats, alfalfa or grass, or are used as meadow (in a close-to-natural state), while many plots have been abandoned over the past ten years. The valuable plant taxa found in this area include *Euphorbia salicifolia*, *Rapistrum perenne*, *Scutellaria hastifolia* and *Dianthus deltoides*.

At this site there is still a thick soil cover above the parent material. The reason for the low erosion rate is partly due to the form of land use, as much of the weed control and soil tillage are done by hand. The other reason for the slower erosion is the shorter slope and a relatively long non-eroded plateau above the arable land that has been covered with alfalfa for the last 6 years. The laboratory data (Table 2) reflect the low-scale use of fertilizers: the AL-P_2O_5 contents of the A, B and C_1 horizons are very low. Some mixing of the soil particles (see K_A values) may have occurred, since the colour of the soil becomes lighter towards the A horizon, suggesting that the lower horizons were disturbed by ploughing or disking.

In the Gömörszőlős area, the basic soil parameters (Table 3) of an arable area were compared with those of a dry slope steppe (situated on the same slope). The differences in the laboratory data suggest that the grassed area was previously used for intensive farming. Significant differences were observed in the AL-P_2O_5 contents of the upper and lower thirds of the slope for both the arable land and the grassland.

Table 1
Laboratory data of the soil profile examined in Gömörszőlős

Soil layer	pH_{KCl}	pH_{H_2O}	$CaCO_3$ (%)	AL-P_2O_5 (mg kg^{-1})	AL-K_2O (mg kg^{-1})	SOM* (%)
A	6.87	8.03	23.9	62.23	253.83	1.57
C	6.86	8.26	23.1	37.33	147.55	0.49

*SOM = soil organic matter

Table 2
Laboratory data of the soil profile examined in Alsószuha

Soil layer	pH_{KCl}	pH_{H_2O}	$CaCO_3$ (%)	AL-P_2O_5 (mg kg^{-1})	AL-K_2O (mg kg^{-1})	SOM* (%)
A	6.07	7.37	0	24.47	127.11	1.84
B	6.54	7.81	0.5	45.26	149.88	0.58
C_1	6.65	7.95	0.6	22.35	178.62	0.53
C_2	6.77	8.13	0.6	128.81	164.06	0.27

*SOM = soil organic matter

Table 3
Laboratory data of the topsoil in Gömörszőlős

Surface cover	Slope	pH_{KCl}	pH_{H_2O}	$CaCO_3$ (%)	AL-P_2O_5 (mg kg^{-1})	AL-K_2O (mg kg^{-1})	SOM*** (%)
Arable land	Upper*	6.68	7.78	21.3	140.84	463.99	2.33
	Lower**	6.81	7.77	7.8	166.36	558.55	3.16
Grassland	Upper	6.71	7.33	19.3	110.14	483.00	3.91
	Lower	6.63	7.16	9.7	181.60	532.20	4.45

*Upper = upper third of the slope, **Lower = lower third of the slope, ***SOM = soil organic matter

In the Alsószuha area, the basic soil parameters of an arable area were compared with those of plots abandoned 10 and 42 years ago and now mostly used for haymaking. As can be seen in Table 4, there were differences in the distribution of the examined soil parameters.

Coenological data on the plant taxa and cover percentages are presented in Tables 5–7. All the plots were previously sown to maize (*Zea mays*), winter wheat (*Triticum aestivum*) or oats (*Avena sativa*).

The first list (Table 5) was prepared for the plot that has been used as a hay meadow for approx. 10 years and was previously used to grow maize and alfalfa. The highest number of plant species was recorded on this plot, probably due to regular mowing, as the removal of biomass from the area may result in the appearance of certain weed species. This plot was oversown with red clover (*Trifolium pratense*). The relatively high rate of dicotyledonous plant species is indicative of a balanced, fairly stable sward.

Table 4
Laboratory data of the topsoil in Alsószuha

Surface cover	Slope	pH_{KCl}	pH_{H_2O}	$CaCO_3$ (%)	AL-P_2O_5 (mg kg^{-1})	AL-K_2O (mg kg^{-1})	SOM*** (%)
Arable land	Upper*	5.41	6.50	0	32.41	162.68	2.55
	Lower**	5.96	6.70	0	90.07	184.35	3.28
Abandoned	Upper	5.32	6.30	0	28.67	141.86	3.01
(10 years	Lower	5.25	6.16	0	20.85	118.72	2.37
Abandoned	Upper	6.47	6.85	0	66.59	166.23	2.50
(40 years)	Lower	5.70	6.37	0	19.58	188.04	2.86

*Upper = upper third of the slope, **Lower = lower third of the slope, ***SOM = soil organic matter

Table 5
Coenological data on a 10-year-old hay meadow in Alsószuha

Species	Cover (%)	Species	Cover (%)
Achillea collina	5	*Lotus corniculatus*	2
Agrimonia eupatoria	1	*Pastinaca sativa*	4
Anagallis arvensis	1	*Picris hieracioides*	1
Artemisia vulgaris	2	*Plantago lanceolata*	3
Calamagrostis epigeios	2	*Plantago media*	5
Centaurea macroptilon	15	*Poa angustifolia*	10
Chrysanthemum leucanthemum	1	*Prunella vulgaris*	3
Cichorium intybus	5	*Ranunculus polyanthemos*	2
Convolvulus arvensis	1	*Setaria glauca*	5
Coronilla varia	3	*Symphytum officinale*	3
Dactylis glomerata	2	*Taraxacum officinale*	5
Daucus carota	3	*Tragopogon orientale*	2
Hypericum perforatum	1–2	*Trifolium pratense*	15
Inula britannica	3	*Trifolium repens*	8
Leontodon hispidus	2	*Verbascum blattaria*	1
Linaria vulgaris	1-2		

The species in the second list (Table 6) were detected in the neighbouring plot, on which cereal production was discontinued approx. 10 years ago, and which is currently more weedy due to the lack of regular mowing. The high (40%) cover of the aggressive weed *Elymus repens* reflects the disturbed state of the land and confirms the lack of regular mowing. The relatively short time that has elapsed since the cereal culture was abandoned was not sufficient for revegetation from nearby natural grasslands, and weed species are dominant because of the poor management. Invasive weeds, however, are absent. The total number of species is also less than on the first plot.

The third list (Table 7) shows the species on the third plot, which was abandoned in 1963 and grazed by sheep until 1990. It is currently uncultivated and in a close-to-natural state. More species were found than on the second plot, but less than on the first. The dominance of *Brachypodium pinnatum* shows that over the last 43 years a secondary grassland (seeded by species from neighbouring patches of natural vegetation) has developed, forming a balanced habitat (slope steppe) with wildflower species in a close-to-natural state. Weed species characteristic of arable land (*Anagallis arvensis, Equisetum arvense, Setaria glauca*) are rare and there are no invasive weeds. The coenological data reflect the fact that the plot was previously used for grazing, as both grass species with great forage value (*Agrostis stolonifera, Brachypodium pinnatum, Festuca rupicola*) (Benyovszky et al., 1995) and weed species typical of pastures (*Eryngium campestre*) were found. *Achillea collina* and *Galium verum* can also be considered as indicators of grazing.

Discussion

The results show that maize cannot provide sufficient protection against phosphorus loss. Grasslands usually gave better results, but it was still perceptible if the land was used for arable farming before being turned into grassland (hay meadows).

Table 6
Coenological data on a plot abandoned and not regularly mowed in Alsószuha

Species	Cover (%)	Species	Cover (%)
Anagallis arvensis	1	*Matricaria inodora*	2
Bromus arvensis	2	*Mentha longifolia*	4
Cichorium intybus	3	*Pastinaca sativa*	2
Cirsium arvense	5	*Setaria glauca*	5
Convolvulus arvensis	3	*Stenactis annua*	4
Daucus carota	1–2	*Symphytum officinale*	2
Elymus repens	40	*Taraxacum officinale*	5
Lathyrus tuber	1	*Trifolium repens*	3
Leontodon hispidus	2		

Table 7
Coenological data on a plot abandoned in 1963 and grazed until 1990 in Alsószuha

Species	Cover (%)	Species	Cover (%)
Achillea collina	2	*Hieracium umbellatum*	3
Agrimonia eupatoria	10	*Knautia arvensis*	2
Agrostis stolonifera	5	*Leontodon hispidus*	4
Anagallis arvensis	1	*Linum catharticum*	2
Brachypodium pinnatum	25	*Lotus corniculatus*	2
Calamintha vulgaris	1	*Ononis arvensis*	2
Cerastium vulgatum	1	*Pimpinella saxifrage*	2
Dorycnium germanicum	5	*Plantago media*	3
Equisetum arvense	1	*Ranunculus polyanthemos*	2
Eryngium campestre	2	*Setaria glauca*	3
Festuca rupicola	5	*Thesium linophyllon*	2
Galium verum	3	*Trifolium pratense*	1

Based on laboratory investigations on various slope angles and soil types (and/or soil characteristics, such as soil structure, soil organic matter content, water management, etc.) recommendations can be made to help farmers choose the necessary measures to protect their land from soil and fertilizer loss.

The composition of plant associations and habitats may differ significantly, depending on the current and previous land use. It is important to know the effects of various types of land use in order to determine the nature protection and economic value of these land use methods.

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